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POTATO BLIGHT AND ANENCEPHALUS IN SCOTLAND

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The theory has recently been put forward by Renwick (1972a) that anencephalus and spina bifida are caused by exposure early in pregnancy to potatoes which are affected by blight or are imperfect for other reasons. In support of this, a temporal correlation was claimed to exist between the severity of blight and the frequency of anencephalus, largely because of a strong correlation between the anencephalic stillbirth rate in Scotland and potato blight severity in the *west* of Scotland over the years 1946-55. Because only a small proportion of potatoes cultivated in Scotland are grown in the west (leading article, 1972), it is improbable that many of the anencephalic fetuses included in the analysis, particularly those in the east and north of Scotland, could have been exposed to any constituents of potatoes grown in the west. A more appropriate and refined analysis of Scottish data has therefore been attempted in the same period, using some unpublished data relating to a more recent period.

METHOD

POTATO BLIGHT

Information on the severity of blight in the east, west, and north of Scotland in the years 1946-55 was taken from the standard monograph by Cox and Large (1960), and also used by Renwick. For the period 1960-69, data on blight on the tubers was supplied by the Potato Marketing Board for each of the nine districts into which Scotland is divided by that body for administrative purposes. These data relate to sample checks carried out at the harvest of maincrop potatoes (mainly in early October) and are expressed as percentages by weight of the crop of the sampled fields affected by blight. To relate these measures of blight in the nine districts to three large regions of Scotland, a mean blight measure was obtained after weighting the districts according to the proportion each constituted of the total acreage of potatoes of a given region. An unknown proportion of potatoes grown in Perth, Angus, and Kincardine, the major seed-producing counties, are not consumed. Different proportions were considered in the analysis and this did not significantly alter the results. In this paper, however, four-fifths of potatoes grown in these areas were arbitrarily assumed to be seed potatoes and excluded from the analysis. The counties constituting these regions are based on the divisions used by Cox and Large and are as follows:

East: The Lothians, Edinburgh, Perth, Berwick, Roxburgh, Selkirk, Peebles, Angus, Fife, Kinross, Clackmannan, Stirling, and Dunfermline.

West: Kirkcudbright, Dumfries, Wigtown, Ayr, Glasgow, Lanark, Renfrew, Dunbarton, Argyll, and Bute.

North: Aberdeen, Banff, Kincardine, Inverness, Ross and Cromarty, Caithness, Sutherland, Nairn, and Moray.

Data were also supplied by the Potato Marketing Board for blight on tubers in Scotland not divided into regions in the years 1960-68, together with some of their unpublished estimates of seed and non-seed potatoes grown in different parts of Scotland in a typical year, to supplement published figures.

ANENCEPHALUS

Figures for anencephalic stillbirths and total births by region of Scotland in the years 1947-56 were taken from standard published sources. For the years 1961-70, the Registrar-General for Scotland provided a special tabulation of anencephalic stillbirths in the east, west, and north of Scotland by month of birth and duration of pregnancy in weeks from the last menstrual period. From these data it was possible to calculate for each region the incidence rate in each yearly quarter for the *initiation* of cases of anencephalus resulting in stillbirth. For this calculation it was assumed that anencephalus is initiated five weeks after the first day of the last menstrual period (LMP). For the total livebirths, a mean gestation length (measured from the LMP) of 40 weeks was assumed, and for total stillbirths this was calculated from published data for Scotland as being 36·8 weeks. The numbers of live and stillbirths by month were obtained from

standard published sources. It was assumed that there was no significant variation in the proportion of births in a given month between the above regions of Scotland. From these data, 'initiation' rates could also be calculated for yearly periods beginning at October 1 to correspond more closely to the main potato crop harvests. These rates represent the frequency of initiation of anencephalic stillbirths, expressed as a proportion of the pregnancies at risk in that particular year or quarter. The denominator, therefore, consists of an estimate of the number of pregnancies resulting in live or stillbirths in which the critical period for the initiation of anencephalus (i.e., five weeks after LMP) occurred during the period in question.

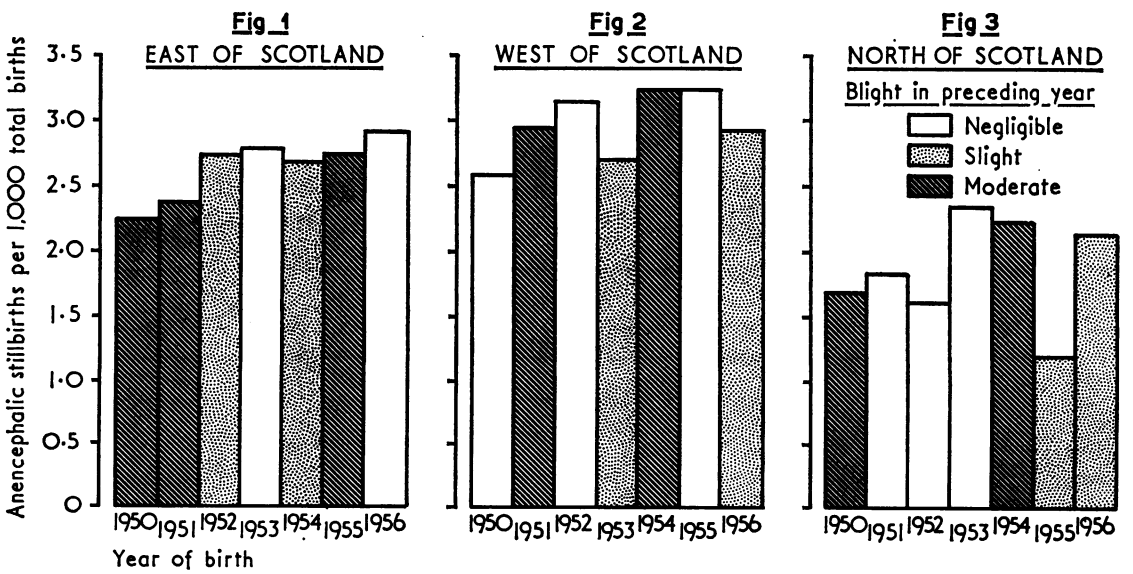
In a few cases, the duration of pregnancy resulting in an anencephalic stillborn is unknown. These cases, amounting to about 10 each year, were assumed to have a gestation length equivalent to the mean for anencephalic stillbirths.

Finally, the published incidence rates of both live and stillborn cases of anencephalus in Scotland by month for the years 1961-69 were examined by the method used by Renwick (1973) in his analysis of data relating to England and Wales. In this method, the rate for the first quarter has been averaged with the rate for the first quarter of the next following year and also corrected for the decreasing trend over these years; and the corrected rate is compared with the percent of blight in potatoes in Scotland over those years.

Results

Figures 1 to 3 show the anencephalic stillbirth rate per 1,000 total births in the east, west, and north regions of Scotland in the years 1946-55 together with the severity of potato blight in the preceding year. No consistent correlation is evident. Because in certain anencephalic stillbirths in a given year conception and initiation of the defect would have occurred before the previous year's main crop harvest in October, the above analysis is to some extent inappropriate. On the other hand, it would have been more inappropriate to relate the frequency of anencephalus to blight severity *two* years previously, as has been done in the case of spina bifida (Renwick, 1972b), which has a slightly greater mean gestation length. Thus, it was possible to calculate that, of babies stillborn with anencephalus in 1963, 58% could have been exposed to main-crop potatoes harvested early in October 1962, and 12% to the 1961 crop before June 1962, while 30% were conceived from June to September of that year when presumably mainly new potatoes would have been eaten.

Table I shows for each of the three regions of Scotland in successive 'potato years' (October-September) and in each yearly quarter the numbers of cases of anencephalus leading to stillbirth that were initiated. The corresponding rates are shown in Table II, together with the appropriate measure of blight. The blight measures are also shown in Figs 4 to 6, together with 'initiation rates' for each



FIGS. 1 to 3. Incidence of anencephalic stillbirths in the east, west, and north of Scotland, 1950-56, and the severity of potato blight in the preceding year.

TABLE I

CASES OF ANENCEPHALUS (LEADING TO STILLBIRTH) INITIATED IN EACH QUARTER 1960-68 BY REGION OF SCOTLAND (ESTIMATED NUMBERS)

	Year of Potato Crop								
	1960	1961	1962	1963	1964	1965	1966	1967	1968
EAST									
October-September	101	88	104	95	80	78	52	81	65
October-December	28	20	23	18	20	19	15	24	16
January-March	22	22	29	27	24	17	12	24	16
April-June	30	23	29	29	21	22	12	18	15
July-September	21	23	23	21	15	20	13	15	18
WEST									
October-September	207	176	193	180	174	138	128	117	114
October-December	64	49	47	32	55	32	33	31	23
January-March	51	40	51	47	38	40	32	36	34
April-June	50	45	54	57	46	35	31	22	29
July-September	42	42	41	44	35	31	32	28	28
NORTH									
October-September	29	17	26	23	17	27	16	12	10
October-December	13	5	6	5	5	3	3	2	2
January-March	13	5	5	10	6	7	5	2	2
April-June	1	3	9	2	2	8	3	2	3
July-September	2	4	6	6	4	9	5	6	3

TABLE II

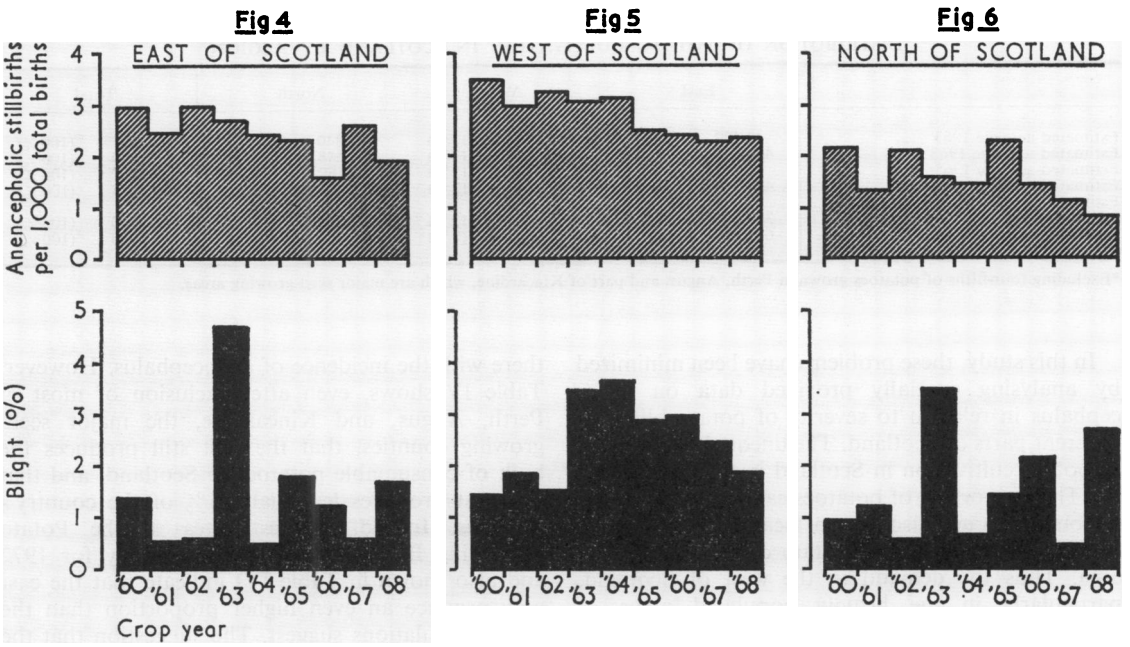
INITIATION RATES OF ANENCEPHALUS AND POTATO BLIGHT IN SCOTLAND, 1960-68, BY REGION

	Year of Potato Crop								
	1960	1961	1962	1963	1964	1965	1966	1967	1968
EAST									
Blight on tubers (% by weight) ..	1·39	0·56	0·57	4·47	0·49	1·91	1·23	0·60	1·72
Anencephalus 'initiation' rate per 1,000:									
October-September	2·91	2·50	2·99	2·72	2·42	2·36	1·61	2·58	2·20
October-December	3·26	2·24	2·60	2·00	2·33	2·29	1·85	3·02	2·13
January-March	2·62	2·55	3·47	3·17	2·98	2·11	1·55	3·14	2·21
April-June	3·54	2·72	3·40	3·44	2·60	2·71	1·49	2·31	2·09
July-September	2·26	2·51	2·54	2·33	1·81	2·33	1·56	1·88	2·36
WEST									
Blight	1·42	1·86	1·53	3·44	3·65	2·90	2·93	2·47	1·89
Anencephalus 'initiation' rate per 1,000:									
October-September	3·60	3·03	3·35	3·11	3·19	2·52	2·40	2·26	2·33
October-December	4·51	3·32	3·22	2·15	3·87	2·33	2·46	2·36	1·86
January-March	3·67	2·81	3·69	3·34	2·85	3·01	2·50	2·85	2·84
April-June	3·57	3·22	3·82	4·09	3·44	2·61	2·33	1·71	2·44
July-September	2·74	2·78	2·74	2·96	2·55	2·18	2·33	2·12	2·22
NORTH									
Blight	0·96	1·22	0·58	3·58	0·70	1·43	2·13	0·46	2·70
Anencephalus 'initiation' rate per 1,000:									
October-September	2·33	1·35	2·08	1·84	1·44	2·28	1·39	1·07	0·94
October-December	4·22	1·56	1·89	1·55	1·62	1·01	1·03	0·70	0·74
January-March	4·32	1·62	1·67	3·28	2·08	2·43	1·80	0·73	0·77
April-June	0·33	0·99	2·94	0·66	0·69	2·75	1·04	0·72	1·17
July-September	0·60	1·22	1·85	1·86	1·34	2·92	1·68	2·10	1·10

TABLE III

POTATO BLIGHT SEVERITY IN SCOTLAND 1960-68 AND ADJUSTED INCIDENCE AND INITIATION RATES OF ANENCEPHALUS

	Year Y (tubers)								
	1960	1961	1962	1963	1964	1965	1966	1967	1968
Percentage (by weight) of tubers visibly blighted in Year Y ..	1·44	1·05	1·01	4·79	1·18	1·69	1·60	0·47	1·59
Incidence of anencephaly per 1,000 in the 12-month period Y + 15									
Not corrected for trend ..	3·638	2·968	3·407	3·101	2·974	2·720	2·321	2·360	2·445
Corrected for trend	3·026	2·509	3·101	2·948	2·974	2·873	2·627	2·819	3·057
Initiation rate of anencephalus (stillbirths only) in 12-month period Oct. (Y)-Sept.	3·22	2·61	3·12	2·84	2·73	2·41	2·05	2·21	2·11



FIGS. 4 to 6. Initiation rates of anencephalic stillbirths in the east, west, and north of Scotland in the potato crop years (Oct.-Sept.) 1960-68 and the corresponding blight severity.

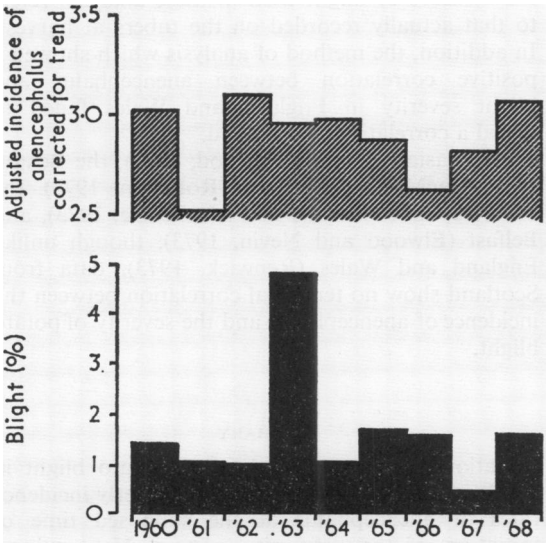


FIG. 7. Potato blight severity and adjusted incidence of anencephalus in Scotland, 1960-68.

year (October-September). Again, no consistent correlation is evident between blight in any region and either the yearly or quarterly rates of initiation of anencephalus.

Figure 7 shows the adjusted incidence rates of live and stillborn cases of anencephalus in Scotland in the years 1961-69 and the blight measure for the preceding year. The rates in this figure have been adjusted by the method used by Renwick (1973) in his analysis of data for England and Wales and referred to above. These rates are also shown in Table III, together with corresponding rates without the correction for trend. As with the other analyses, no correlation between the frequency and severity of blight can be seen. Table III also shows that there is no correlation between blight severity and the yearly initiation rates of anencephalus in Scotland considered as a whole.

DISCUSSION

Any attempt to relate information about potatoes at harvest time and the incidence of anencephalus is complicated by two problems. First, it is difficult to know where the potatoes grown in a particular area will be consumed, and, second, published figures of anencephalus do not include tabulations of month of birth by duration of gestation. Consequently, the incidence of initiation of anencephalus at different times of year, assuming that this occurs around the fourth week of gestation, cannot be precisely calculated.

TABLE IV
DISTRIBUTION OF POTATO CULTIVATION IN SCOTLAND BY REGION

	East		West		North		Total	
Estimated acreage 1963	45,272	(60%)	10,080	(13%)	20,840	(27%)	76,192	(100%)
Estimated tonnage 1963	404,651	(59%)*	88,080	(13%)	184,548	(27%)	677,279	(100%)*
Estimated acreage 1965	45,702	(60%)*	9,320	(12%)	21,180	(28%)	76,202	(100%)*
Estimated tonnage 1965	474,510	(60%)*	94,134	(12%)	211,804	(28%)	780,448	(100%)*
Estimated tonnage excluding seed potatoes 1972	383,000	(74%)	64,000	(12%)	69,000	(13%)	516,000	(100%)
Estimated total tonnage 1972 ..	653,000	(73%)	72,000	(8%)	165,000	(19%)	890,000	(100%)

*Excluding four-fifths of potatoes grown in Perth, Angus, and part of Kincardine, which are major seed-growing areas.

In this study, these problems have been minimized by analysing specially provided data on anencephalus in relation to severity of potato blight in different parts of Scotland. The unequal distribution of potato cultivation in Scotland is shown in Table IV. The proportion of potatoes eaten in a particular region which are also grown locally will obviously depend on the extent of potato cultivation in that area. Thus the demand in the west of Scotland, particularly in the heavily populated areas of Clydeside, greatly exceeds the locally grown supply, and large quantities have to be imported from the east of Scotland. However, it is reasonable to suppose that those potatoes that *are* grown there will also in the main be eaten there. Thus, a comparison of anencephalus and blight severity in the west of Scotland is not unreasonable. However imperfect this correlation may be, it seems preferable to relating anencephaly in the *whole* of Scotland with blight in the west (Renwick, 1972a). In contrast, since in the east an excess of potatoes is grown for local needs, it is fair to assume that most potatoes eaten there are locally grown.

No consistent correlation was found in any of the analyses, either for the country as a whole or for any of its three regions, between anencephalus and blight severity. Furthermore, this applied both to the yearly rates and to the quarterly rates of initiation of the defect. These findings are in keeping with the recent analysis of data relating to the Edinburgh area (Smith, Watt, Boyd, and Holmes, 1973). The hypothesis might suggest that the frequency with which anencephalus would be initiated would be higher in the first quarter of the year than in the preceding quarter as a result of deterioration caused by storage of potatoes harvested in the previous October. Similarly, this rate might be expected to be still higher in the second quarter when overwintered potatoes would be at their worst (Renwick, 1973). However, there was *no* consistent tendency for this to occur. It has been suggested that potatoes in the east are used largely for seed purposes (Renwick 1972c) so that a correlation is not to be expected there with the incidence of anencephalus. However, Table IV shows, even after exclusion of most of Perth, Angus, and Kincardine, the major seed-growing counties, that the east still produces the bulk of consumable potatoes in Scotland, and that the west produces less than 15% of the country's potatoes. Indeed, the estimates of the Potato Marketing Board (readily available only for 1972 and also shown in Table IV) indicate that the east may produce an even higher proportion than the above calculations suggest. The suggestion that the lack of correlation between blight in the east and north of Scotland reflects more effective control in these areas (Renwick, 1972c) cannot be upheld since the measure of blight used in these analyses refers to that actually recorded on the tubers at harvest. In addition, the method of analysis which showed a positive correlation between anencephalus and blight severity in England and Wales failed to reveal a correlation in Scotland.

Like eastern Canada (Elwood, 1973), the Boston area (MacMahon, Yen, and Rothman, 1973), the Irish Republic (Elwood and Mackenzie, 1973), and Belfast (Elwood and Nevin, 1973), though unlike England and Wales (Renwick, 1973), data from Scotland show no temporal correlation between the incidence of anencephalus and the severity of potato blight.

SUMMARY

National and regional data on potato blight in Scotland were compared with the quarterly incidence rates of anencephalus at the supposed time of initiation of the deformity *in utero*. No temporal correlation was found.

I am most grateful to the Registrar-General for Scotland and to Mr. James Travers for providing the special tabulation of anencephalic stillbirths; to the Potato Marketing Board for data on potato cultivation and blight in Scotland; and to Professor Sir Richard Doll and Dr. N. Wald for their helpful comments.

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